

1. Apparatus for hemodialysis treatment, comprising:

a dialyzer having a flow path for a patient's blood and a flow path for a dialysate solution and a semipermeable membrane configured to separate the blood flow path from the dialysate flow path; and

5 an ultrasonic transducer configured to deliver ultrasonic energy into the dialyzer.

2. The apparatus of claim 1, wherein:

the semipermeable membrane of the dialyzer is configured as a hollow fiber membrane.

10 3. The apparatus of claim 1, further comprising:

an acoustic coupling for coupling ultrasonic energy from the ultrasonic transducer into the dialyzer.

15 4. The apparatus of claim 3, wherein:

the dialyzer is configured with a cylindrical body; and

the acoustic coupling is configured with two halves, each of the two halves having an approximately semicylindrical cutout configured to fit around the cylindrical body of the dialyzer.

20 5. The apparatus of claim 1, further comprising:

at least one waveguide rod for coupling ultrasonic energy from the ultrasonic transducer into the dialyzer.

6. The apparatus of claim 1, further comprising:

an ultrasonic waveform generator connected to the ultrasonic transducer.

5 7. The apparatus of claim 6, wherein:

the ultrasonic waveform generator is switchable between modes, including a narrowband sine wave, a variable or sweeping frequency sine wave and a broadband square or sawtooth waveform.

10 8. The apparatus of claim 6, wherein:

the ultrasonic waveform generator is configured to vary the frequency within a desired range to find a resonant frequency and to lock onto the resonant frequency.

9. The apparatus of claim 6, wherein:

15 the ultrasonic waveform generator has a low power setting effective to increase the diffusion rate across the semipermeable membrane of the dialyzer and a high power setting effective to break up thrombus that forms within the dialyzer.

10. The apparatus of claim 1, further comprising:

20 a chamber downstream of the dialyzer;

an emboli detector for detecting thrombi and emboli entering the chamber from the dialyzer; and

an ultrasonic transducer configured to break up thrombi and emboli in the chamber.

11. The apparatus of claim 10, further comprising:

5 a filter configured to prevent thrombi and emboli larger than a predetermined size from entering the patient's circulatory system from the chamber.

12. Apparatus for hemodialysis treatment, comprising:

10 a dialyzer having a flow path for a patient's blood and a flow path for a dialysate solution and a semipermeable membrane configured to separate the blood flow path from the dialysate flow path;

a chamber downstream of the dialyzer;

an emboli detector for detecting thrombi and emboli entering the chamber from the dialyzer; and

15 an ultrasonic transducer configured to break up thrombi and emboli in the chamber.

13. The apparatus of claim 12, further comprising:

20 a filter configured to prevent thrombi and emboli larger than a predetermined size from entering the patient's circulatory system from the chamber.

14. A method of hemodialysis treatment, comprising:

connecting a patient's circulatory system to a dialyzer having a flow path for the patient's blood and a flow path for a dialysate solution and a semipermeable membrane configured to separate the blood flow path from the dialysate flow path; and delivering ultrasonic energy into the dialyzer.

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15. The method of claim 14, wherein:

ultrasonic energy is delivered into the dialyzer at a power level effective to increase the diffusion rate across the semipermeable membrane of the dialyzer.

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16. The method of claim 14, wherein:

ultrasonic energy is delivered into the dialyzer at a power level effective to break up thrombus that forms within the dialyzer.

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17. The method of claim 14, wherein:

ultrasonic energy is delivered into the dialyzer at a power level effective to increase the diffusion rate across the semipermeable membrane of the dialyzer; and

ultrasonic energy is intermittently delivered into the dialyzer at a power level effective to break up thrombus that forms within the dialyzer.

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18. The method of claim 14, further comprising:

detecting thrombi and emboli entering a chamber downstream of the dialyzer; and energizing an ultrasonic transducer to break up thrombi and emboli in the chamber.